Renewable Energy and Energy Efficiency of the XXI Century

OPTIMIZING ANTI-REFLECTION LAYERS FOR PEROVSKITE LATERAL HETEROJUNCTION SOLAR CELLS

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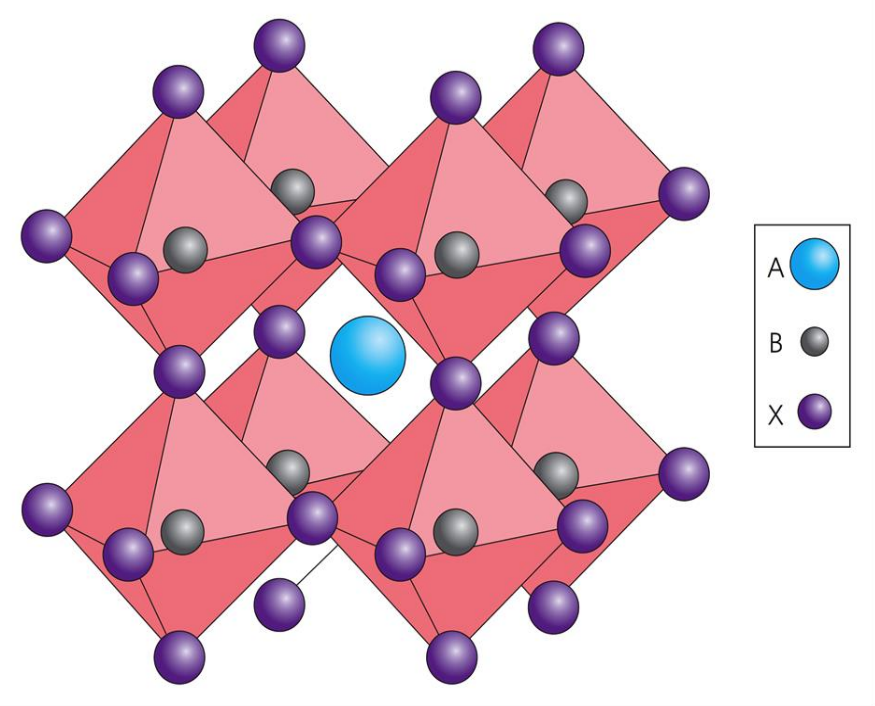

A - Cs, MA (Metilammonium)

FA (Formamidinium)

MA – CH3NH3, FA – CH5N2

B – Pb, Sn **X** – F, Cl, I, Br

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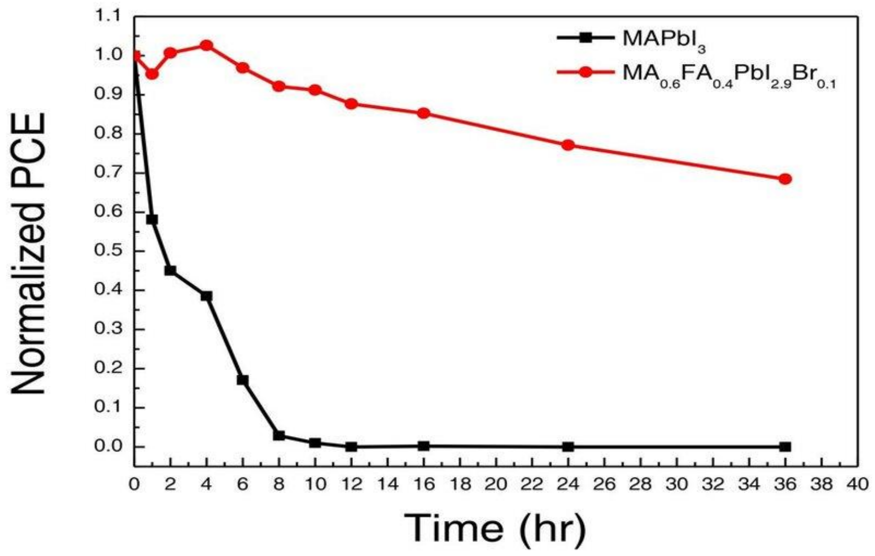
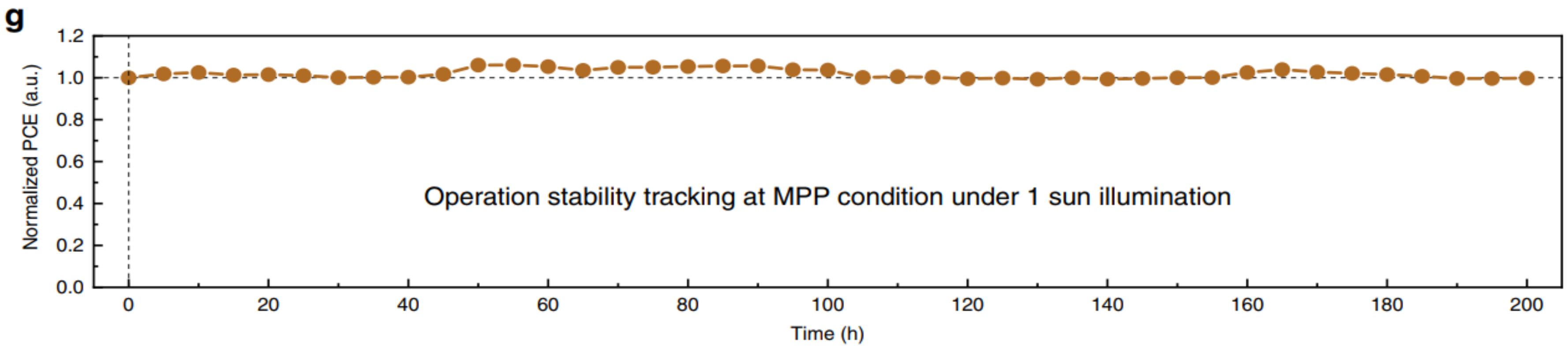
Why perovskites?

- High absorption coefficient in thin films
- Low exciton binding energy
- Long diffusion length
- Tunable band gap
- Radiation-resistant, suitable for space applications
- Easy to synthesize
- Flexible



Traditional perovskite-based solar cell



Lateral perovskite-based solar cell

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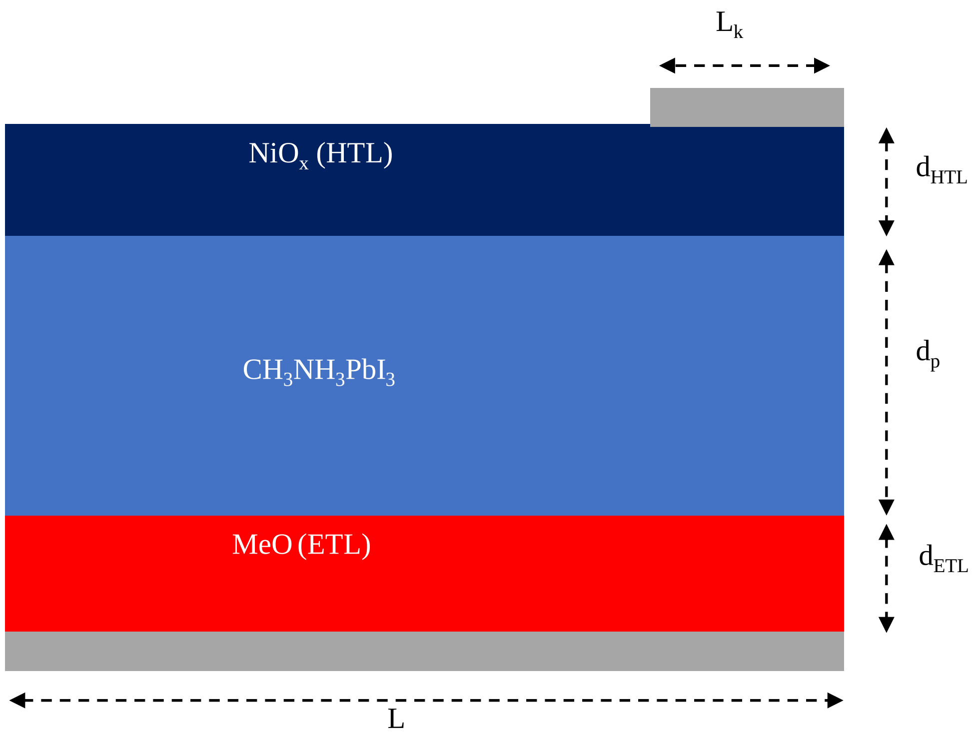
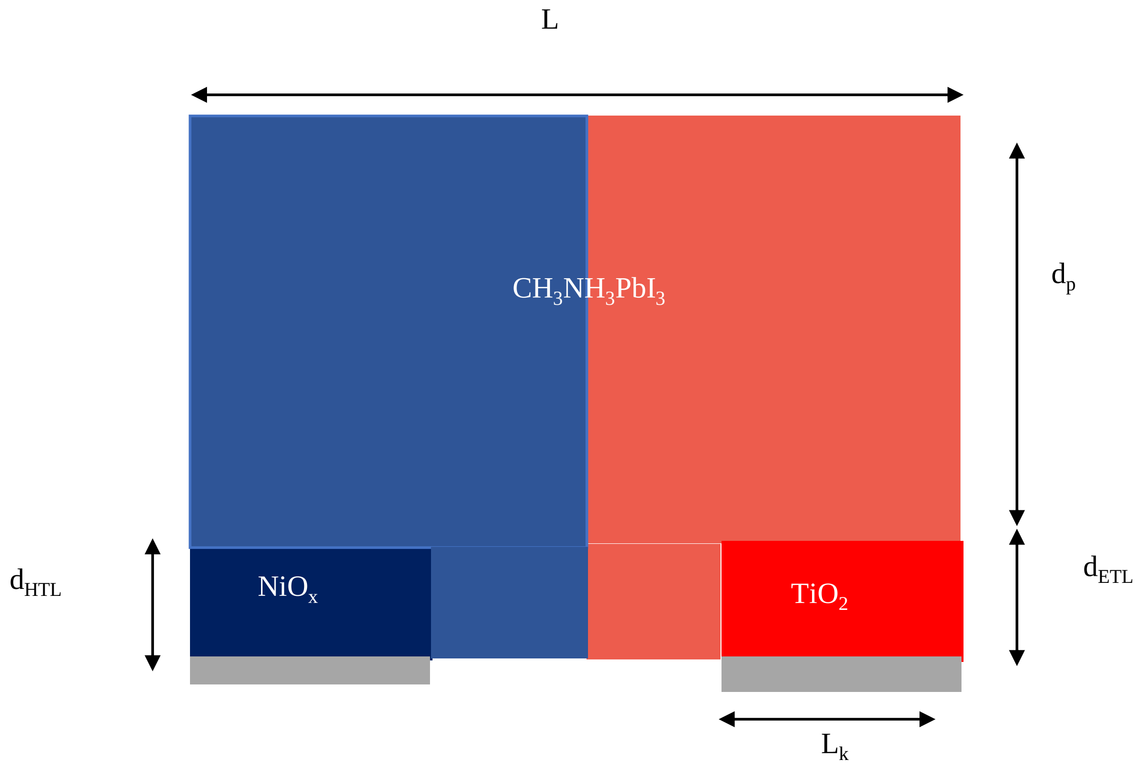
Geometrical models of standard and lateral heterojunction solar cells

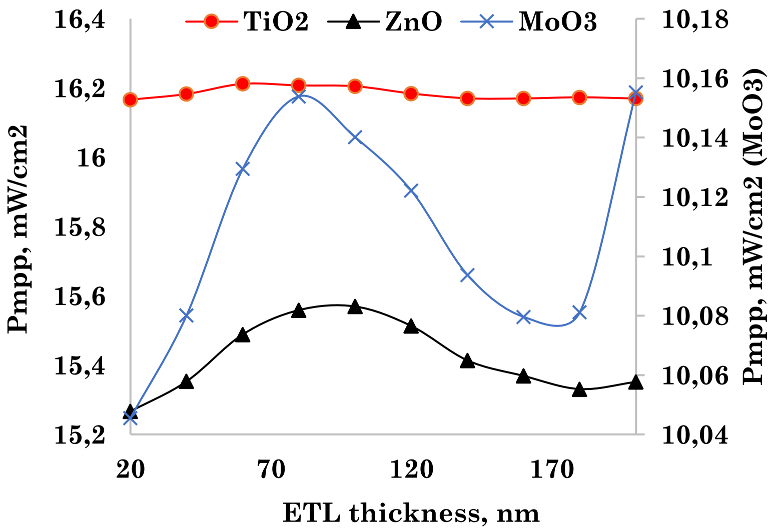


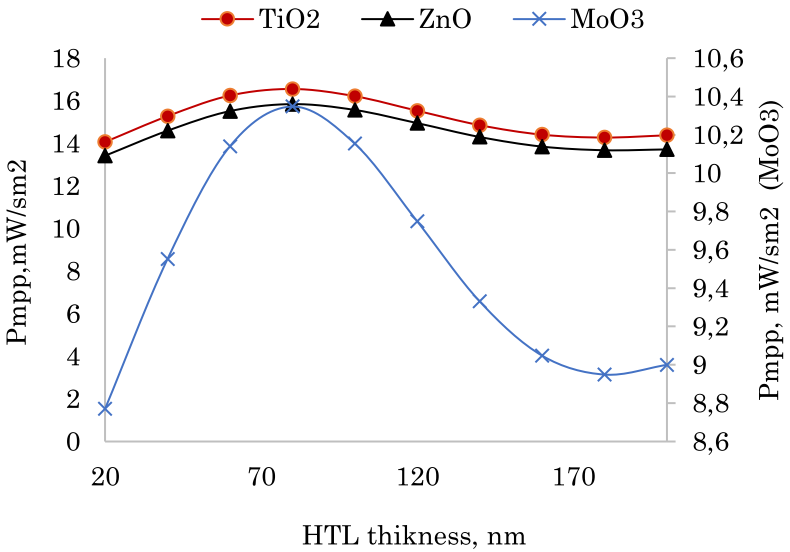
Traditional structure

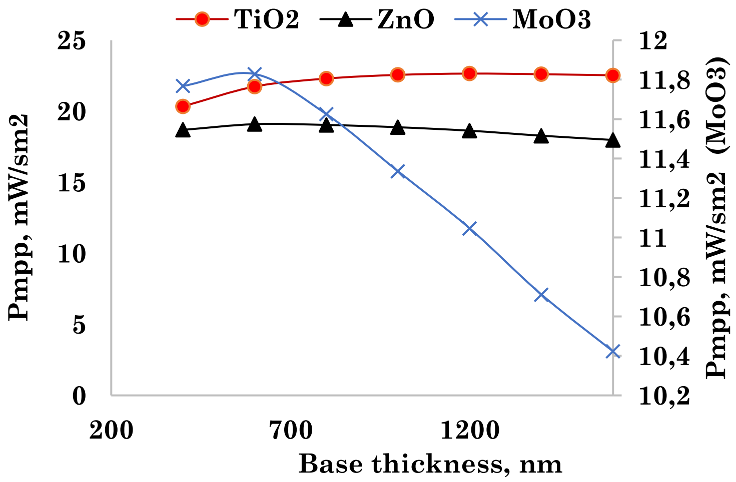


Lateral structure

Brief results of traditional perovskite-based solar cell



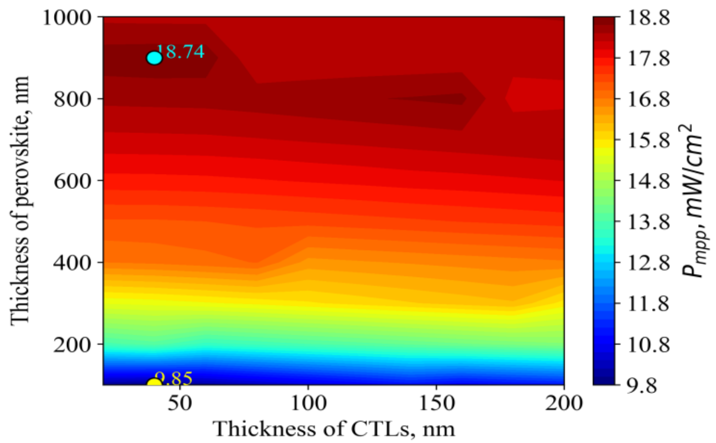




Materials	d_{BASE}, nm	d_{ETL}, nm	d_{HTL}, nm	J_{SC}, mA/sm^2	U_{OC}, V	P_{mpp}, mW/sm^2	FF, %	η, %
MoO_3	600	80	80	21.12	1.188	11.83	47.14	18.69
TiO_2	800	60	80	21.83	1.176	22.29	86.83	35.21
ZnO	600	100	80	21.20	1.188	19.09	75.78	30.16

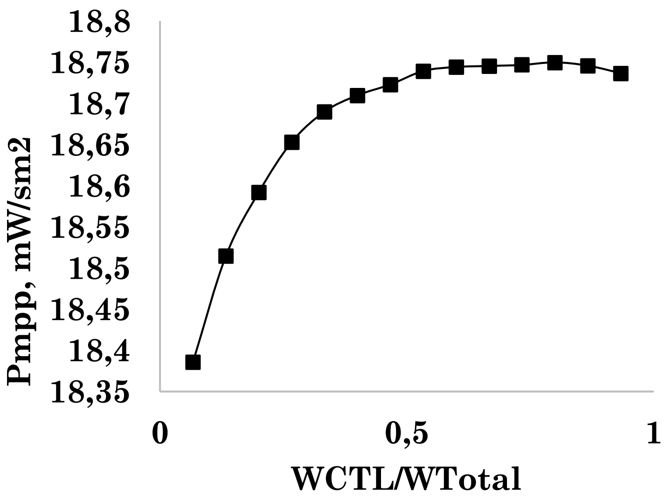
Main photoelectric parameters of the perovskite-based solar cell with optimized thicknesses of the ETL layer, HTL layer, and perovskite layer.

Optimization of lateral geterojunction solar cell



$d_{perovskite}$, nm	$D_{ETL,HTL}$, nm	J_{sc}, mA/cm^2	U_{oc},V	P_{mpp}, mW/cm^2	FF, %	η, %
100	40	9.74	1.182	9.85	85.5	15.56
900	40	18.72	1.171	18.74	85.5	29.60

The main photoelectric parameters of the best and the worst solar cells.

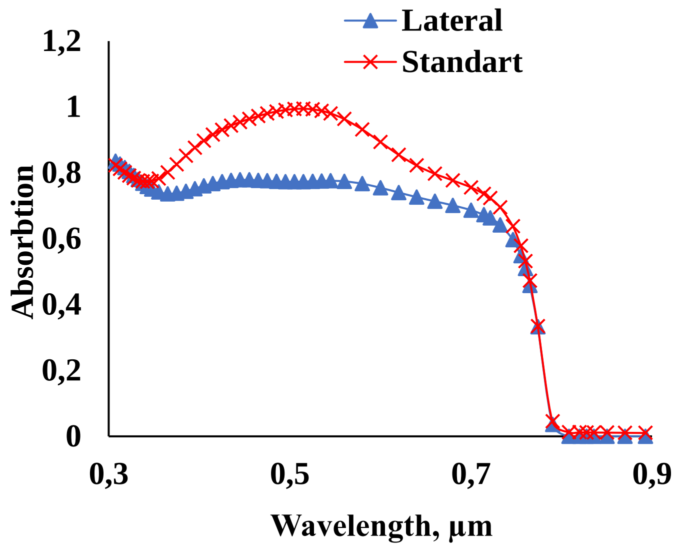


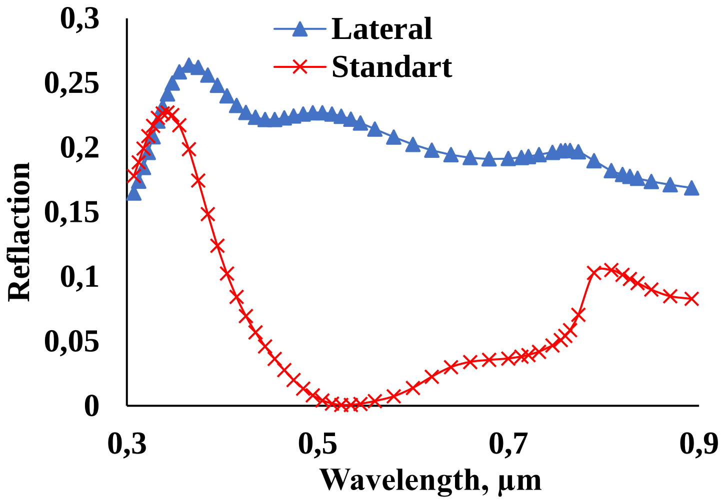
$l_{ETL,HTL}$, nm	J_{sc}, mA/cm^2	U_{oc},V	P_{mpp}, mW/cm^2	FF, %	η, %
100	18.87	1.17	18.39	83.28	29.04
1200	18.74	1.16	18.75	85.97	29.62

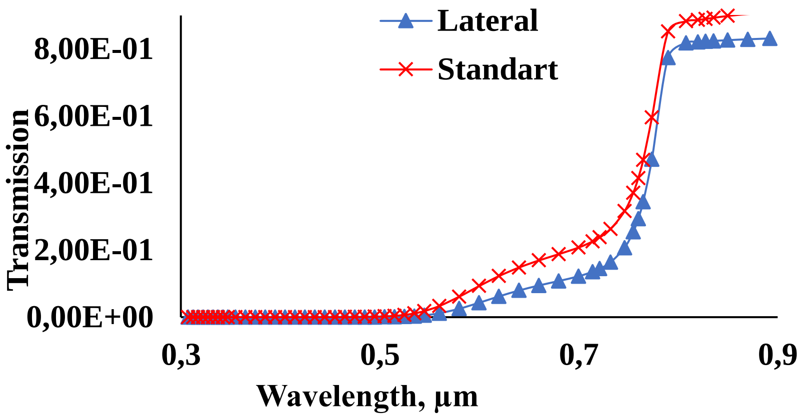
The main photoelectric parameters of the best and worst lateral heterojunction solar cells when the perovskite layer thickness is 900 nm, the width is 3 μm, and the ETL and HTL layer widths are varied from 100 nm to 1400 nm in increments of 100 nm.

Comparision of lateral and traditional perovskite solar cells

Strukture	$d_{perovskite}$, nm	J_{sc}, mA/cm^2	U_{oc}, V	P_{mpp}, mW/cm^2	FF, %	η, %
Lateral	400	18.62	1.182	18.87	85.80	29.84
Traditional	400	19.59	1.188	20.34	87.41	32.13







material	thicknes, nm	U_{oc}, V	I_{sc}, mA/sm^2	P_{mpp}, mW/sm 2	FF, %	n_{eff}, %
SiO_2	90	1.176	21.39	20.45	86,31	34.31
Al_2O_3	70	1.182	21.47	21.78	85,87	34.42
Si_3N_4	60	1.176	20.92	21.23	86,27	33.53

The table below presents the main photovoltaic parameters of the perovskite-based lateral heterojunction solar cells with anti-reflection coatings at their optimal thicknesses (SiO_2, Al_2O_3, and Si_3N_4).

6 Conclusion

1. The performance of traditional perovskite solar cells was analyzed by optimizing the thickness of each layer. Three ETL materials — ZnO, MoO_3, and TiO_2 — were investigated. Among them, TiO_2 demonstrated the best photovoltaic performance. The optimal HTL thickness was found to be **80 nm** for all investigated ETL materials, while the optimal perovskite layer thickness was **600 nm** for ZnO and MoO_3, and **800 nm** for TiO_2. After optimization, the solar cell using TiO_2 as the ETL achieved the highest efficiency of **35.21%**, significantly outperforming the ZnO- and MoO_3-based devices.

2. The performance of perovskite-based lateral heterojunction solar cells was investigated through geometrical optimization of the ETL, HTL, and perovskite layers. The optimized thicknesses were found to be **900 nm** for the perovskite layer and **40 nm** for the charge transport layers (CTLs). The optimal widths of both the ETL and HTL layers were determined to be **1200 nm**.

3. the perovskite-based lateral heterojunction solar cell with an anti-reflection coating achieved a power conversion efficiency of **34.42%**. This value is **1.16** times higher than that of the structure without an anti-reflection coating, which had an efficiency of **29.9%**.

Thank you for your attention!